

What is claimed is:

1. An optical logic device for processing information optically using the transmitted and/or reflected characteristics of at least one stable, non-absorbing optical hard limiter.

2. The optical logic device of claim 1, wherein the at least one stable, non-absorbing optical hard limiter comprises alternating layers of materials with different linear indices and oppositely signed Kerr coefficients.

3. The optical logic device of claim 1, wherein the transmitted characteristics of a stable, non-absorbing optical hard limiter comprise:

a first range bounded by input signals in the range of approximately zero to I_1 in which the transmitted output signal of the stable, non-absorbing optical hard limiter is approximately zero;

a second range bounded by input signals in the range approximately from I_1 to I_2 in which the transmitted output signal of the stable, non-absorbing optical hard limiter increases from zero to I_2 ; and

a third range bounded by input signals in the range above approximately I_2 in which the transmitted output signal of the stable, non-absorbing optical hard limiter is approximately I_2 , where I_1 is approximately half of I_2 .

4. The optical logic device of claim 1, wherein the reflected characteristics of a stable, non-absorbing optical hard limiter comprise:

a first range bounded by input signals in the range of approximately zero to I_1 in which the reflected output signal of the stable, non-absorbing optical hard limiter is approximately equal to the input signal;

a second range bounded by input signals in the range approximately from I_1 to I_2 in which the reflected output signal of the stable, non-absorbing optical hard limiter decreases from approximately I_1 for an input signal of I_1 to approximately zero for an input signal of I_2 ; and

5 a third range bounded by input signals in the range above
approximately I_2 in which the reflected output signal of the stable, non-
absorbing optical hard limiter is increases as the input signal increases above
 I_2 , where I_1 is approximately half of I_2 .

5. An optical gain element for converting an optical input signal having
an intensity substantially from the set $\{0, I_1\}$ to an optical output signal having
an intensity substantially from the set $\{0, I_2\}$, where I_1 is approximately half of
 I_2 , the all-optical gain element comprising:

10 a first stable, non-absorbing optical hard limiter operably coupled to
receive as its input a combination of the optical input signal and a signal
having an intensity of approximately $4 I_1$ combined in an approximately 80:20
ratio;

15 a second stable, non-absorbing optical hard limiter operably coupled to
receive as its input a combination of the transmitted output signal from the
first stable, non-absorbing optical hard limited and a signal having an
intensity of approximately $5 I_1$ combined in an approximately 80:20 ratio; and

20 a third stable, non-absorbing optical hard limiter operably coupled to
receive as its input a combination of the transmitted output signal from the
second stable, non-absorbing optical hard limited and a signal having an
intensity of approximately $4.88 I_1$ combined in an approximately 80:20 ratio
and to output its transmitted signal as the output of the optical gain element.

25 6. An optical AND gate comprising a stable, non-absorbing optical hard
limiter operably coupled to receive as its input a combination of a first input
signal and a second input signal combined in an approximately 50:50 ratio
and to output its transmitted signal as the output of the optical AND gate,
wherein:

30 the combined input signal is approximately zero and the output of the
optical AND gate is approximately zero when both the first input signal and
the second input signal are zero;

the combined input signal is approximately I_1 and the output of the optical AND gate is approximately zero when the first input signal is zero and the second input signal is I_2 ;

the combined input signal is approximately I_1 and the output of the optical AND gate is approximately zero when the first input signal is I_2 and the second input signal is zero;

the combined input signal is approximately I_2 and the output of the optical AND gate is approximately I_2 when the first input signal is I_2 and the second input signal is I_2 ; and

I_1 is approximately half of I_2 .

7. An optical OR gate comprising an optical gain element for converting an optical input signal having an intensity substantially from the set $\{0, I_1\}$ to an optical output signal having an intensity substantially from the set $\{0, I_2\}$, wherein the optical gain element is operably coupled to receive as its input a combination of a first input signal and a second input signal combined in an approximately 50:50 ratio and to output the converted signal as the output of the optical OR gate, and wherein:

the combined input signal is approximately zero and the output of the optical OR gate is approximately zero when both the first input signal and the second input signal are zero;

the combined input signal is approximately I_1 and the output of the optical OR gate is approximately I_2 when the first input signal is zero and the second input signal is I_2 ;

the combined input signal is approximately I_1 and the output of the optical OR gate is approximately I_2 when the first input signal is I_2 and the second input signal is zero;

the combined input signal is approximately I_2 and the output of the optical OR gate is approximately I_2 when the first input signal is I_2 and the second input signal is I_2 ; and

I_1 is approximately half of I_2 .

8. An optical XOR gate comprising:

a stable, non-absorbing optical hard limiter operably coupled to receive as its input a combination of a first input signal and a second input signal combined in an approximately 50:50 ratio; and

5 an optical gain element for converting an optical input signal having an intensity substantially from the set $\{0, I_1\}$ to an optical output signal having an intensity substantially from the set $\{0, I_2\}$, the optical gain element operably coupled to receive as its input a reflected signal from the stable, non-absorbing optical hard limiter and to output the converted signal as the
10 output of the optical XOR gate, wherein:

the combined input signal is approximately zero, the reflected signal is approximately zero, and the output of the optical XOR gate is approximately zero when both the first input signal and the second input signal are zero;

15 the combined input signal is approximately I_1 , the reflected signal is approximately I_1 , and the output of the optical XOR gate is approximately I_2 when the first input signal is zero and the second input signal is I_2 ;

the combined input signal is approximately I_1 , the reflected signal is approximately I_1 , and the output of the optical XOR gate is approximately I_2 when the first input signal is I_2 and the second input signal is zero;

20 the combined input signal is approximately I_2 , the reflected signal is approximately zero, and the output of the optical XOR gate is approximately zero when the first input signal is I_2 and the second input signal is I_2 ; and
 I_1 is approximately half of I_2 .

25 9. An optical NOT gate comprising:

a stable, non-absorbing optical hard limiter operably coupled to receive as its input a combination of an input signal and a fixed signal of approximate intensity I_2 combined in an approximately 50:50 ratio; and

30 an optical gain element for converting an optical input signal having an intensity substantially from the set $\{0, I_1\}$ to an optical output signal having an intensity substantially from the set $\{0, I_2\}$, the optical gain element operably coupled to receive as its input a reflected signal from the stable, non-

absorbing optical hard limiter and to output the converted signal as the output of the optical NOT gate, wherein:

the combined input signal is approximately I_1 , the reflected signal is approximately I_1 , and the output of the optical NOT gate is approximately I_2

when the input signal is zero;

the combined input signal is approximately I_2 , the reflected signal is approximately zero, and the output of the optical NOT gate is approximately zero when the input signal is I_2 ; and

I_1 is approximately half of I_2 .

10. An optical NAND gate comprising:

an optical AND gate; and

an optical NOT gate operably coupled to an output of the optical AND gate for logically inverting the output of the optical AND gate, wherein the optical AND gate and the optical NOT gate are based on stable, non-absorbing optical hard limiters.

11. An optical NOR gate comprising:

an optical OR gate; and

an optical NOT gate operably coupled to an output of the optical OR gate for logically inverting the output of the optical OR gate, wherein the optical OR gate and the optical NOT gate are based on stable, non-absorbing optical hard limiters.